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EMERGING TECHOLOGIES FOR THE PRESERVATION OF RECORDS

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In 1839, John Benjamin Dancer, an Englishman, coupled photography with microscopy for the first time to produce microphotographs of a page of text. He employed the Daguerreotype photographic process in his experiments. Twenty years later, Sir David Brewster further disclosed how microphotographs could be concealed in small places like an ink blot. The German Army, in World War II, adopted this principle in a technique called "microdot." Information was transmitted to its agents by hiding microphotographs of secret messages in the punctuation marks contained in book print.

The French government, during the Franco-Prussian War, used microphotography to communicate dispatches into Paris when the city was under siege. As many as 3,000 messages could be photographed and reduced on one collodion plate. A surface layer called a "pellicle" was then peeled from the plate as a thin film. This lightweight film was rolled into a scroll, slipped into a quill, and attached to a pigeon's tail feather. When the pigeon reached Paris, the film was recovered from the quill, projected, and the messages copied by hand. "Pigeon Post" was the forerunner of the familiar V-mail process employed by the U.S. in World War II.

Microfilm is the principal method known to man for compressing graphic and textual data without alteration of information content. Libraries use it extensively for space reduction of archival files of newspapers, periodicals, and books. In addition to compacting passive files, industry and government are using microfilm more and more as the keystone of active and dynamic information systems. As long as information can be stored more densely on microfilm than on magnetic tape, microphotography

will be an attractive and important medium for micro-recording printed and graphical data.

Silver-Halide is the most popular photo-recording medium. It is fast, grainy, exposed with white light, and developed wet. Within the last few years, several companies announced a process by which silver-halide films can also be developed dry. Silver-halide films are most popular for recreation and home use, as well as commercial application. Diazo film was introduced many years ago. It consists of a Mylar base coated with a photosensitive dye. It is slower than silver, exposed with ultraviolet light, and developed by ammonia vapor. Ultraviolet light disintegrates portions of the dye compounds and ammonia vapor brings out the remaining dye in the coating. Since the dye imbeds itself in the film, the intelligence at once becomes visible to the human eye. More recently another recording medium was introduced called Kalvar. In the Kalvar process a plastic film is coated with microscopic gas bubbles. On exposure, the bubbles are excited by an ultraviolet light source. The film is developed dry by heating it to a temperature equivalent to that of a warm iron. Heat causes the excited bubbles to burst and form light scattering centers. The unaffected coating that remains on the surface provides the intelligence for the picture.

Diazo and Kalvar are quick, dry, and offer acceptable resolution characteristics for most applications. Because both processes are also dry, they have an important advantage over the silver-halide family of films which still require chemical development and fixing.

While most microfilm and microimage applications now in use employ either silver-halide or diazo film as the recording medium, a new scientific

process called photochromics has also been introduced as a practical means for high density storage of textual and graphic images.

Photochromic coatings are similar to photographic emulsions in appearance and other properties. They can be coated on the same type of surfaces as photographic emulsions and exhibit excellent resolution capabilities. The basic principle behind the photochromic process is the ability of individual molecules in the coating to switch alternately from a colored to a colorless state. The materials switch when subjected to near ultraviolet radiation and back to the colorless state when subjected either to heat or visible light. With photochromics, the molecular coating can be exposed with ultraviolet radiation and erased with white light. It is this reversible characteristic that gives Photochromic Microimages (PCMI) a powerful advantage in film technology. It is grain free, thus permitting the recording of very high density micro-images. It also exhibits excellent gray scale characteristics which facilitate the recording of both textual and graphic information in the same medium. The reversible feature enables inspection, error detection and correction, and at the same time provides a method for adding and subtracting information. Photochromics brings to film technology some of the same power that magnetic recording brought to computer technology.

High-density microrecording is feasible with PCMI at linear reductions of 200 to 1, representing an area reduction of 40,000 to 1.

COMPRESSED FORMS OF STORAGE

Images in microform may be stored in two principal forms: 1) sequentially, and 2) individually.

Sequentially:

As spools or reels of 35mm or 16mm film.

This has been the traditional method used for archival records, for newspapers and journals, and for inactive files. Spools may be handled manually or placed into cartridges for automatic threading and loading in viewing equipment.

Individually:

Many different types exist:

The microfilm jacket--small strips of microfilm are inserted into sleeves of an acetate jacket;

The aperture card--one or more microfilm images are mounted into adhesive bordered windows in an opaque card;

The microfiche--a sheet of film which carries many images in rows and columns;

The microtape--a contact print is made from 16mm film onto adhesive backed paper which is then cut and pasted on file cards;

The microcard--a contact print is made from 16mm film onto a photosensitive opaque card.

Microforms are currently available in both black and white and color. Color is generally about five times more expensive. The technical problem in the production of color microfiche has been the maintenance of consistent color fidelity in making copies from a master.

Some American companies are considering major microform publishing programs. They intend to make entire libraries of material available as packages to institutional subscribers. Ultra microfiche libraries are those published at reduction ratios greater than 100:1. The largest single producer

of microfiche is the U.S. Government. Some 15,000,000 microfiche were distributed last year covering technical and research reports published by the Department of Defense, NASA, Atomic Energy Commission, and the Office of Education. Government microfiche are produced at 17:1 which provides for about 60-70 pages to the microfiche.

Of the different microforms, microfiche seems to be capturing the most attention and interest. My own organization, EDUCOM, has itself announced plans for a MICROBOOK program that will place the contents of a college library book collection on microfiche. On the basis of one book to one microfiche, and a reduction ratio of 42:1, we estimate that 20,000 books could be comfortably housed in a cabinet 3'x 12'x 1 1/2'. Questions of fair return to publishers for copyright, availability of a suitable reader, and the willingness of students to use film are all fundamental to the success of the program.

MEANS FOR VIEWING AND REPLICATION

Printed material which is compressed into a microform calls for auxiliary equipment--inspection viewers, service viewers, and printing equipment for individual page copying. Equipment on the market makes it possible to view any microform and obtain, if needed, a copy of all or part of a page in a matter of seconds. Devices that fall into this category provide pushbutton copying, frame-by-frame, using manual, semi-automatic, or fully automatic auxiliary means. By using high speed xerographic printers and automatic binding equipment, it is possible to produce page enlargements from a microfilm of a book and reassemble them into hard covers. Machines are also available for making duplicate copies of film whether in sequential

or unit form.

Despite the plethora of machines available for viewing and printing, modern technology has not yet produced an inexpensive, portable microfilm or microfiche reader. Affectionately dubbed the "cuddly microfiche reader" the device should be light weight, about the size of a book, possess a good light source, and sell for under $50. Several manufacturers are working on these specifications but thus far no one company has demonstrated equipment.

A portable reader is certain to promote increased use of microfilm and microfiche in schools and in the home.

MEANS FOR IMAGE RETRIEVAL

Ever since Dr. Vannevar Bush proposed a Memex machine in 1946, there has been a rash of equipment designed to combine the dense-storage capability of film with the searching speed of electronics.

Systems with names like MINICARD, MEDIA, and WALNUT are examples of very sophisticated equipment designed for customers with highly specialized needs and large capacity files.

Simpler systems like MIRACODE, SELECTRIEVER, and FILESEARCH are available for commercial application and these are in use at several locations.

Most prevalent, however, are machines like Eastman Kodak's LODESTAR which, with a minimum of advance indexing, automatically locates a desired page from among the 1200 images on a 100 foot spool of film. Houston Fearless' CARD is an equivalent device which, in four seconds, will locate

any one ima ge from among 7000 stored on microfiche.

Access to a time shared computer enables some users to logically process a complex indexing search request at a computer terminal before going to a simple microform look-up device to consult the basic references.

Electronic Printing

The digital computer has had a major influence on emerging film technologies and methods. Because a computer can process and generate information much faster than a mechanical printer can print, new means were sought to synchronize the computer's output speed with the recording speed of film. A number of interesting methods have been invented.

The Photon is typical of a class of machines designed to accept information on film under the control of a computer produced tape. Linking film with a computer offers great composing versatility. In the Photon machine, photographic images of the characters of several type fonts are contained as etches in annular rings on a specially designed disc. The disc rotates at very high speed, and on each rotation, the computer tape causes a light beam to be projected through a selected etched character on the disc. This burst of illumination focuses the image of the character through a lens and exposes it on a strip of film. Thus, at very high speed, the contents of an entire page can be rapidly and automatically composed using a variety of type font styles and sizes while at the same time the computer controls column width, height, and page layout.

Companies like Stromberg-Carlson, Eastman Kodak, Control Data Corporation, and RCA have also developed special equipment for the

electronic composition of textual and graphic information on film. Each uses a different kind of technology but all are designed to achieve the same purpose. For example, at the heart of Stromberg-Carlson's machine is a charactron tube which is very similar to a television picture tube. Inside the tube, in front of the electron gun, is a small circular metallic mask. The mask has tiny holes in it which form the shapes of letters and numbers. Under computer control, a tiny electron beam passes through the mask to illuminate a particular letter as a photographic exposure on film, or to project it as a glow on a TV phosphor screen causing that letter to be visible from the front of the set. The entire operation is so fast that an entire page of information can be photographed or projected several times a second.

In 1966, Minnesota Mining and Manufacturing Company announced a new machine especially designed for computer-microfilm systems. Whereas most computer-to-film systems require chemical processing of the exposed film, 3M's Electron Beam Recorder (EBR) converts the digital language of the computer directly to microfilm images using dry silver film. Electron beam recording is achieved by writing, under computer control, with a sharp pencil of light through an optical system onto film. A latent image is formed on the film surface where the beam strikes and this image is made immediately visible without using wet chemical process.

These developments are only typical of a myriad of others underway today. All search for new ways to harmonize the power of electronic technology with the recording power of film in order to generate creative

and useful applications.

Telecommunications

Telecommunications technology can bring graphics and film together even if the two are geographically separated. The electrical transmission of pictures, maps, and other printed matter and its faithful recording at a distance is called "facsimile". Its first application to film was demonstrated in 1952 when RCA scanned a film copy of Margaret Mitchell's GONE WITH THE WIND on the stage of the Coolidge Auditorium at the Library of Congress in Washington and produced a duplicate film copy in San Francisco moments later.

The upgrading of our domestic communications systems through the introduction of broad band communications channels increases the likelihood that microfilm will be used in the future as the receiving medium for various forms of communications. Signals generated by a computer, a video camera, or a facsimile scanner, can be transmitted efficiently and faithfully received and recorded on film provided broad band channels of communication exist to bridge the sender and receiver. This is not economically feasible today because we are obliged to use standard voice grade telephone lines but these costs will come down as more coaxial cables, microwave stations, and satellites begin to assume a greater share of the national communications burden.

Holography

A part of the new technology which especially fires the imagination of those interested in micrographics is the LASER and its ability to produce holograms.

The word LASER stands for Light Amplification by Stimulated Emission of Radiation. Its theoretical beginnings can be traced back half a century, but the idea lay dormant until 1951 when Charles H. Townes, an American physicist, developed a practical method for changing the natural balance of low-energy molecules into a high-energy state and then stimulating them to emit their amplified energy. The emission is in the form of a powerful, narrow, coherent beam of light which can be concentrated to a micron width; that is, a point of light on the order of a hundred thousandth of an inch wide.

This strange kind of light possesses some interesting properties besides its ability to stay narrow. Waves of coherent light consistently maintain their relative spacing which means that by shining a beam of light between two objects and knowing the wavelength, the distance between them can be measured very accurately. In part, it is this property of consistent wave spacing that makes the production of holograms possible.

The word "hologram" originated with Dr. Dennis Gabor, a British scientist. In the late 1940's, while experimenting with the invention of a new mciroscope, Dr. Gabor made a special kind of picture, using coherent light, which he called a hologram; the word is derived from the Greek words meaning whole picture.

A normal photographic plate records dark and light spots as a function of the intensity of illumination on the object being photographed. Laser photography does the same but in addition it records information about the distances from the object as well. This is done by splitting the laser beam into two parts. One part shines on the photographic plate as a reference,

the other is projected on the object and the reflected light waves also reach the plate. The two coincident sets of light waves are said to interfere because the reflected light is out of phase according to the contours and surfaces of the object. These differences in wave length produce spots on the plate which are a record of the third dimension. The plate is then developed like ordinary photographic film. After processing, it looks dull and gray to the naked eye. However, when viewed with a coherent light source all of the information on the plate becomes visible including dark, light, and distance information; and, this supplies the full third dimensional image. Really, it's more than just a three dimensional picture; the distance information is so completely and exhaustively recorded that the viewer perceives he is actually seeing around the object just as he does in the real world. This is the incredible new technique of holography.

The fact that three dimensional information can be stored in microscopic form on film opens up an entire new world of micrographic applications.

CONCLUSION

My aim this morning has been to describe briefly some of the new technologies in the field of microforms of graphic records. Emerging microform technology offers a potential far beyond that of merely preserving records. It heralds the beginning of a new era in information transfer which is rapidly becoming a powerful force in the business and educational affairs of our society.